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Combined Load Test Fixture

*Donald J. Baker
U.S. Army Research Laboratory
Vehicle Technology Directorate
Langley Research Center, Hampton, Virginia*

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Donald J. Baker
U.S. Army Research Laboratory
Vehicle Technology Directorate
Langley Research Center, Hampton, Virginia

National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23681-2199

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Abstract

A test fixture has been developed at NASA Langley Research Center that has the capability of applying compression load and shear load simultaneously to a test specimen. The test specimen size is 24-inches by 28-inches. This Technical Memorandum describes the test specimen design, test specimen preparation, fixture assembly in the test machine, and a test operation plan.

Introduction

The purpose of this Technical Memorandum is to document a Combined Load Test Fixture (CLTF) developed at NASA Langley Research Center (LaRC) and to provide guidance for test specimen preparation, installation, and testing. This CLTF has the unique capability of applying compression load and shear load simultaneously to the test specimen.

The CLTF evolved from a shear test fixture described in Reference 1 where the load from a tensile test machine is applied to a test frame which in turn applies a shear load to the edges of the shear test specimen (see figure 1a). The fixture pivot points are at the corners of the test specimen to allow the rectangular test specimen to deform into a parallelogram configuration. This shear test fixture differs from the usual 'picture frame' shear test fixture where the load is applied at the pivot pins which are not necessarily at the corners of the test specimen. The CLTF is a modification to the shear test fixture, as illustrated in figure 1b. The compression load (P) is applied using a standard test machine. The shear load (S) is applied by a hydraulic actuator through a self reacting load mechanism that includes a load cell to measure the shear load. This shear load causes the frame to transform from a rectangle to a parallelogram thus inducing the shear strain in the specimen. The frame pivots at the corners of the specimen to minimize any other strain components induced into the test specimen. The top member of the shear load introduction frame is attached to the test machine upper platen. No shear load is reacted by the test machine. The frame is slotted at the lower corner pins to allow specimen shortening from the compression load. The rollers between the test machine lower platen and the test fixture allow lateral shear load application while the test specimen is under a compression load. A photograph of the CLTF with a specimen located in the test machine is shown in figure 2. The shear loading mechanism contains a self-reacting load frame with the hydraulic actuator at one end of the frame and a load cell at the opposite end.

In the present configuration this fixture can test a 24-inch by 28-inch specimen in combined compression and shear loading where the 28-inch dimension is parallel to the compression load direction. The specific CLTF being discussed in this document was designed for operation in the 300-kip compression test machine located in the Structures and Materials Laboratory (Building 1148) at NASA LaRC.

Test Specimen Design

The information contained in this section is for guidance in the design of a test specimen to be used in the CLTF. Figure 3 shows the minimum size blank of material necessary for fabrication of a panel with a 24-inch x 28-inch test area. Ideally, at least 1.0 inch should be added to the overall dimensions to allow for trim. The 28-inch dimension is along the compression loading axis and the sides parallel to the 28-inch length will be called “vertical sides” in the context of this document. Before any machining is conducted on the specimen blank, it is necessary to determine how the test specimen will be oriented in the CLTF (which end is the top and which side faces away from the 300 kip test machine console during the test). This identification is necessary since the hole/slot patterns are not necessarily symmetric about either centerline of the test specimen. It should also be noted that if it is planned to use the Vision Image Correlation System (VIC-3D)¹ system for stereophotogrammetric measurement of displacement and strain data, the cameras and camera support frame must be located on the side of the test specimen facing away from the console.

Figure 4 shows the configuration of the finished machined test specimen prior to installation of the tabs. (Note that in this figure the test specimen has been rotated 90° such that the “vertical” compression direction is oriented from side-to-side on the page.) The specimen has to be machined to the final configuration before installing tabs because the holes/slots in the specimen are 1/32-inch larger than the holes/slots in the tabs. These oversized holes/slots prevent the load from being introduced directly into the test specimen. The fixture itself should be used to mark the locations and/or match drill the holes/slots. The 0.50-inch radius cutouts in the corners are only to accommodate specimen deformation and are not associated with the CLTF corner pins. Fabrication details for the vertical and horizontal tabs are shown in figures 5 and 6, respectively. Grooves are machined in the vertical tabs as shown in figure 5. The fabricator has the option of drilling a small hole in each end of the tabs and in the test specimen to assist in locating the tabs on the specimen during the adhesive bonding operation that occurs later in the assembly process. The tabs are manufactured from steel with a minimum strength of 125 ksi. Options for the tab material selection include 4130, 4340, and 17-4 PH corrosion resistant steels. The tab thickness needs to be determined for each test specimen. The total test specimen edge thickness (including the front and back tabs) needs to be within the range of 0.25 inch to 0.53 inch as shown in figure 7. (Note that in this figure the test specimen has been rotated 90° such that the “vertical” compression direction is oriented from side-to-side on the page.) All tabs must be of equal thickness.

It is recommended that the tabs be bonded to the test specimen with a high-strength adhesive that cures at room temperature. The bonding surfaces on the tabs and the test specimen should be properly prepared and the appropriate bondline thickness should be maintained as per the instructions for the adhesive. The vertical tabs are bonded such that the grooved side is in contact with the test specimen as shown in Detail A of figure 7. After the adhesive has cured the grooves in the vertical tabs are cut through as shown in Detail A of figure 7 to produce a segmented tab. Use caution not to heat the tab while machining and thereby degrade the bond

¹ The use of trademarks or names of manufacturers in this report is for accurate reporting and does not constitute an official endorsement, either expressed or implied, of such products or manufacturers by the National Aeronautics and Space Administration.

strength. Verify that the specimen end does not protrude past the edges of the horizontal tabs. For cases where the specimen protrudes, trim the specimen flush with the tabs.

Two pairs of back-to-back strain gages need to be located as shown in figure 7 to determine if a uniform compression load is being applied to the test specimen. More strain gages can be applied as determined by the test engineer. If the VIC-3D system is being used, the surface of the test specimen that will be monitored by the cameras should be prepared with the desired speckled pattern. Note that strain gages and the speckled pattern should be applied to the specimen prior to installation into the frame and the test fixture.

Specimen/Frame Subassembly

Figure 8 shows the frame that is attached to the perimeter of the test specimen. This frame provides the interface between the test specimen and the CLTF. The eight frame members are identified by the letters A through H stamped into the frame member. The near side, shown in figure 8, faces away from the control console of the 300-kip test machine. Frame members B, D, E, and F are on the near side of the frame assembly whereas members A, H, G, and C are on the far side of the assembly. If the VIC-3D system is used to record displacement data, the cameras and support frame must be located on the side facing away from the console of the 300 kip test machine due to space considerations in this particular laboratory. The frame members must be installed as shown in figure 8. The eight corner pins are installed as shown in figure 9. The pins are stamped with two letters into the pin head that identify the pin location in the fixture. For example, the pin with the letters A & H on the head would be located at the corner where member A and member H join. The pin head is not shown in figure 9 and is opposite the end shown. The pin head fits into a recess in the horizontal member of the frame to retain the pin during a test.

Experience has determined that it is easier to install the test specimen in the frame then install this subassembly into the test fixture assembly. (However, after testing the first specimen in a series of specimens, it may be more efficient to leave the specimen frame attached to the CLTF and insert the next specimen directly into the frame.) A photograph of the subassembly is shown in figure 10 where the frame has been attached to the test specimen. In the specimen preparation process the specimen sides were to be identified so the proper specimen orientation could be obtained within the frame. The 3/8-inch diameter and 1/2-inch diameter bolts used to attach the frame to the test specimen are high-strength socket-head shoulder screws. The 3/8-inch and 1/2-inch diameter bolts at the top and bottom (the horizontal member as shown in Figure 8) of the assembly are torqued to the appropriate bolt specifications. After these bolts are installed, the 3/8-inch and 1/2-inch diameter bolts in the vertical members are installed finger-tight.

Combined Load Test Fixture (CLTF) Installation

This section describes installation of the CLTF and the test specimen into the 300-kip test machine located in the Structures and Materials Laboratory at NASA LaRC.

Compression Platen Alignment

Verify that the large swivel head platen is installed on the upper crosshead of the test machine. Loosen the adjustment bolts on the upper compression platen. Bring the upper and lower platens together and load to 20,000 lbs. Tighten the adjustment bolts. Unload and allow for a small gap between the platens. Check the gap with a feeler gage to verify that the platens are parallel.

Upper Platen Assembly

Install the Upper Plate, Large Reinforcer, Spacer, and Short Reinforcer to the upper compression platen as shown in figure 11. The Large Reinforcer is located to the rear side (building wall side) of the 300-kip test machine. Tighten all bolts.

Lower Platen Assembly

Install the Guides on the Lower Plate. Install the Lower Plate, Long Reinforcer, and Short Reinforcer to the test machine lower platen as shown in figure 12. The Long Reinforcer is located on the front side of the test machine. Install the Roller Assembly into the Roller Frame.

Specimen/Frame Subassembly Installation

The specimen/frame subassembly (previously shown in figure 10) is installed on the upper “L” bracket of the CLTF as shown in figure 13a. Note that the open holes in the “L” bracket (previously shown in figure 9) determine the location of the frame on the “L” bracket. The “L” bracket is designed to accept a longer frame side, if necessary. Install the bolts between the upper “L” bracket and the specimen/frame subassembly. After the specimen/frame subassembly is in place, the rollers, frame guide, frame ends, and lower “L” bracket can be installed (Figure 13b). Install the bolts between the subassembly and the lower “L” bracket. Tighten all the bolts in the upper and lower “L” brackets as per the bolt manufacturer's torque specification.

If linear variable displacement transducers (LVDTs) are to be used to measure the out-of-plane displacement of the test specimen, they should be installed at this point in the CLTF assembly process. The LVDT support bracket filler plates are installed as shown in figure 14. The filler plates attach to the vertical members of the frame and fill the spaces at the edge of the test area. The interior holes have to line up with the edge of the test area. If the holes in the existing filler plates do not locate the LVDTs at the desired location, additional holes can be drilled and tapped in the filler plates. The screws attaching the filler plates to the frame are to be tight whereas the screws attaching the LVDT brackets to the filler plates should not be completely tightened. These screws need to allow the bracket to rotate on the filler plate as the test specimen frame changes from a rectangle to a parallelogram. Figure 14 also shows two string potentiometers that are used to record the test specimen length change.

Shear Load Mechanism Installation

At this point the shear load introduction mechanism needs to be installed. This mechanism, as

shown in figure 15, consists of the 80-kip Hydraulic Actuator, two shear load reaction bars, and a 100-kip load cell. The actuator and the shear load parameters are controlled by an automated test controller that can take the compression load signal from the test machine and ratio it to control the shear load. It is desirable for the controller to have the capability to exceed the compression-to-shear load ratio of 1.0 so that a high shear load and low compression load can be tested.

Test Operation Plan

The following is a framework for a test operation plan. The test engineer will need to adapt this plan for the particular test specimen and the required test conditions.

1. Read all of the previous sections on the specimen design/preparation and the CLTF assembly.
2. Complete the specimen/frame subassembly.
3. Install the specimen/frame subassembly into the CLTF. Install and torque fasteners. Install the shear load mechanism.
4. System Checkout Test: Apply a compression load only. The load is to be determined by the test engineer. Check for a uniform compression load in the specimen by comparing the results from the four strain gages shown in figure 7. If necessary the upper compression platen may have to be adjusted to achieve a uniform compression load. Remove load.
5. Set up the shear load controller to obtain the desired shear load as a percentage of the compression load.
6. Set up and calibrate the VIC-3D system if it is being used to obtain the full field displacement measurement.
7. Apply a compression load (stay in the linear range) and verify the shear load is the desired value. Remove the load.
8. Ready to test the specimen: Apply compression load at a low load rate. It is necessary to maintain a low load rate so the shear load can be maintained at the desired percentage throughout the test.
9. Upon test completion: remove the load, remove the shear load reaction bars, and remove the specimen.

References

1. Farley, G., L. and Baker, D., J.; "In-plane Shear Test of Thin Panels," Experimental Mechanics, Vol. 23, No 1,81-88, March 1983.

Figures

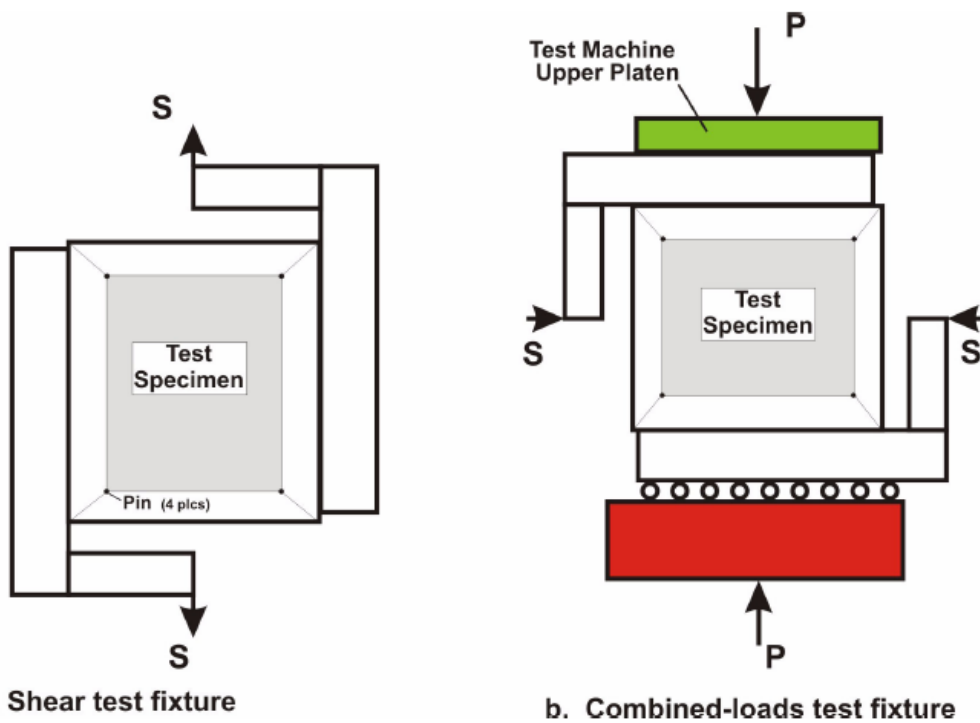


Figure 1. Evolution of the Combined Load Test Fixture (CLTF) concept.

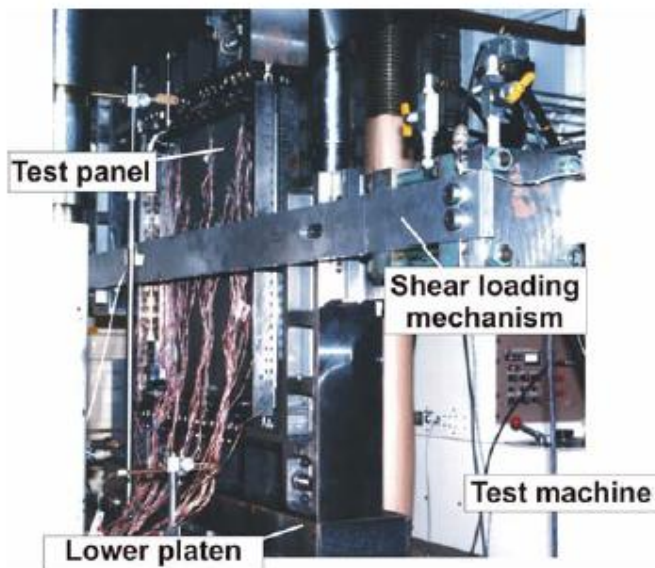


Figure 2. Photograph of the CLTF and a test specimen installed in test machine.

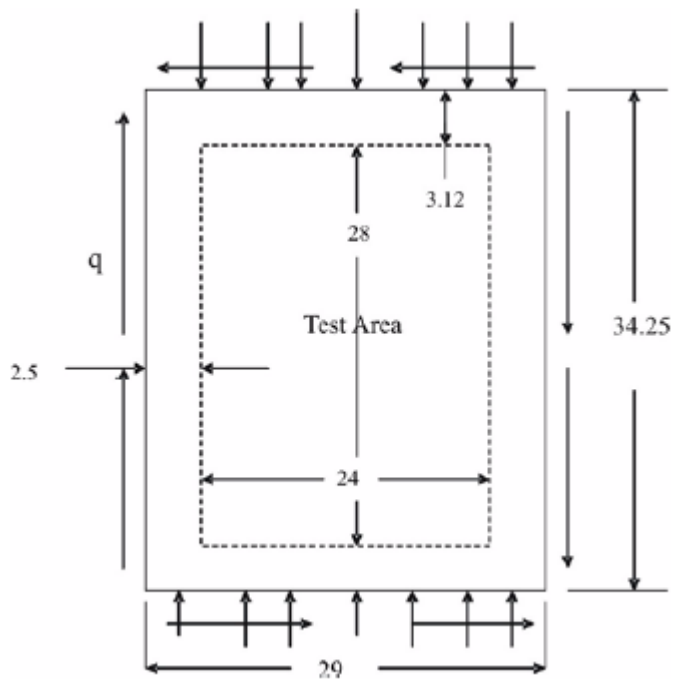


Figure 3. Minimum size of material blank needed for 24-inch by 28-inch test specimen. (All dimensions are in inches.)

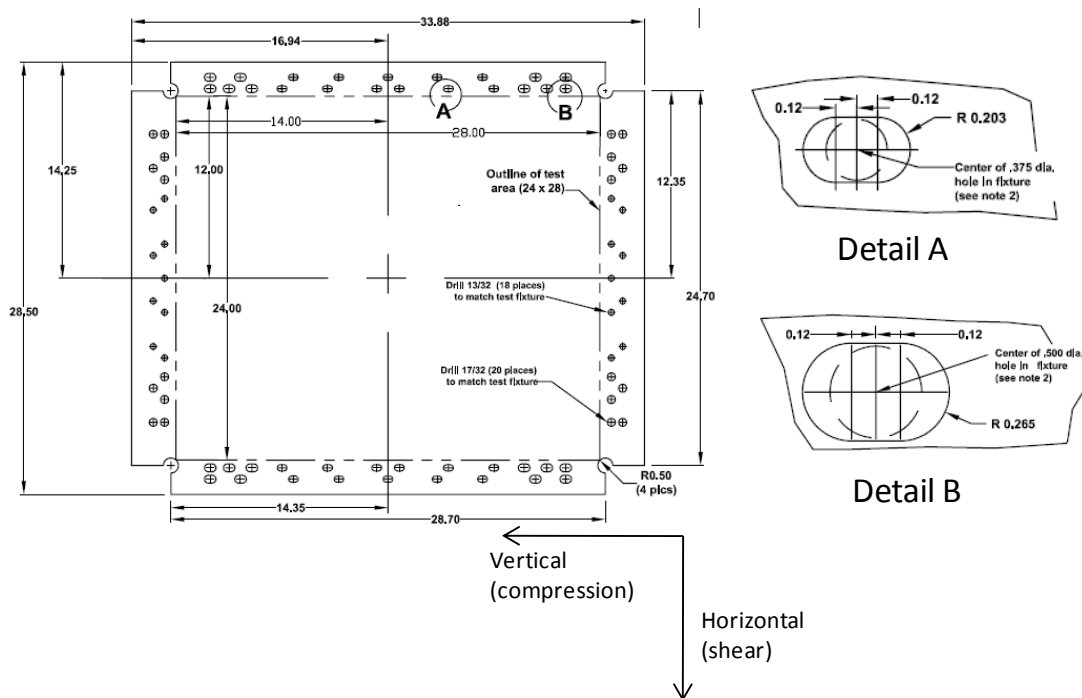


Figure 4. Final test specimen configuration. (All dimensions are in inches.)

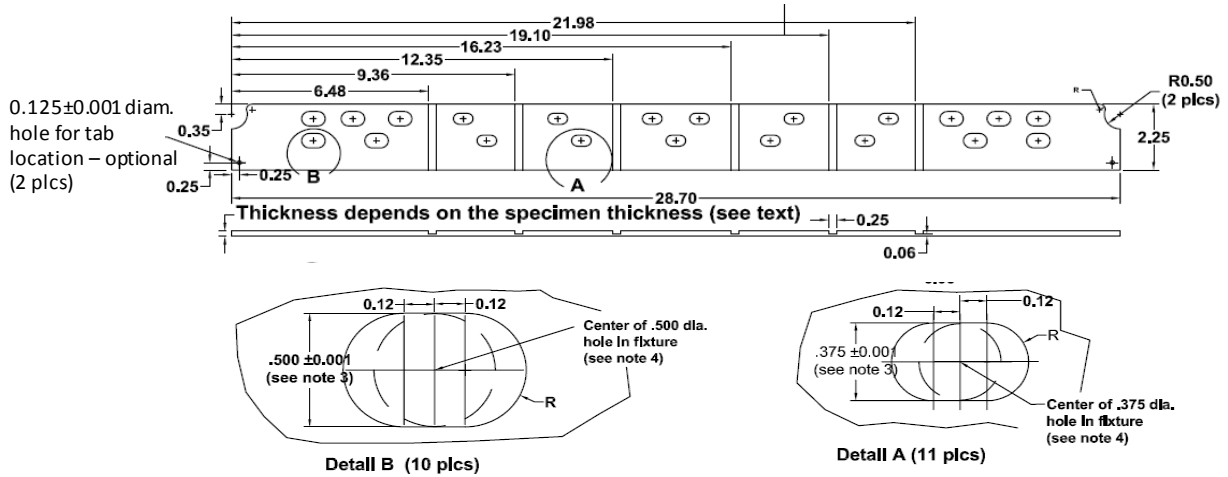


Figure 5. Vertical tab detail. (All dimensions are in inches.)

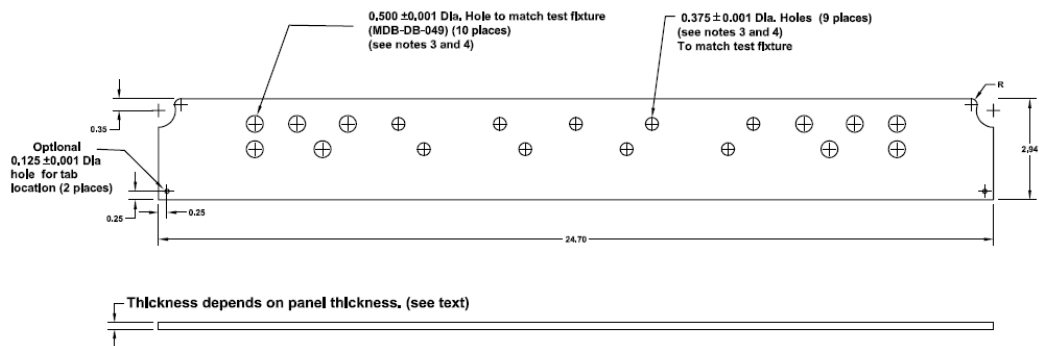


Figure 6. Horizontal tab detail. (All dimensions are in inches.)

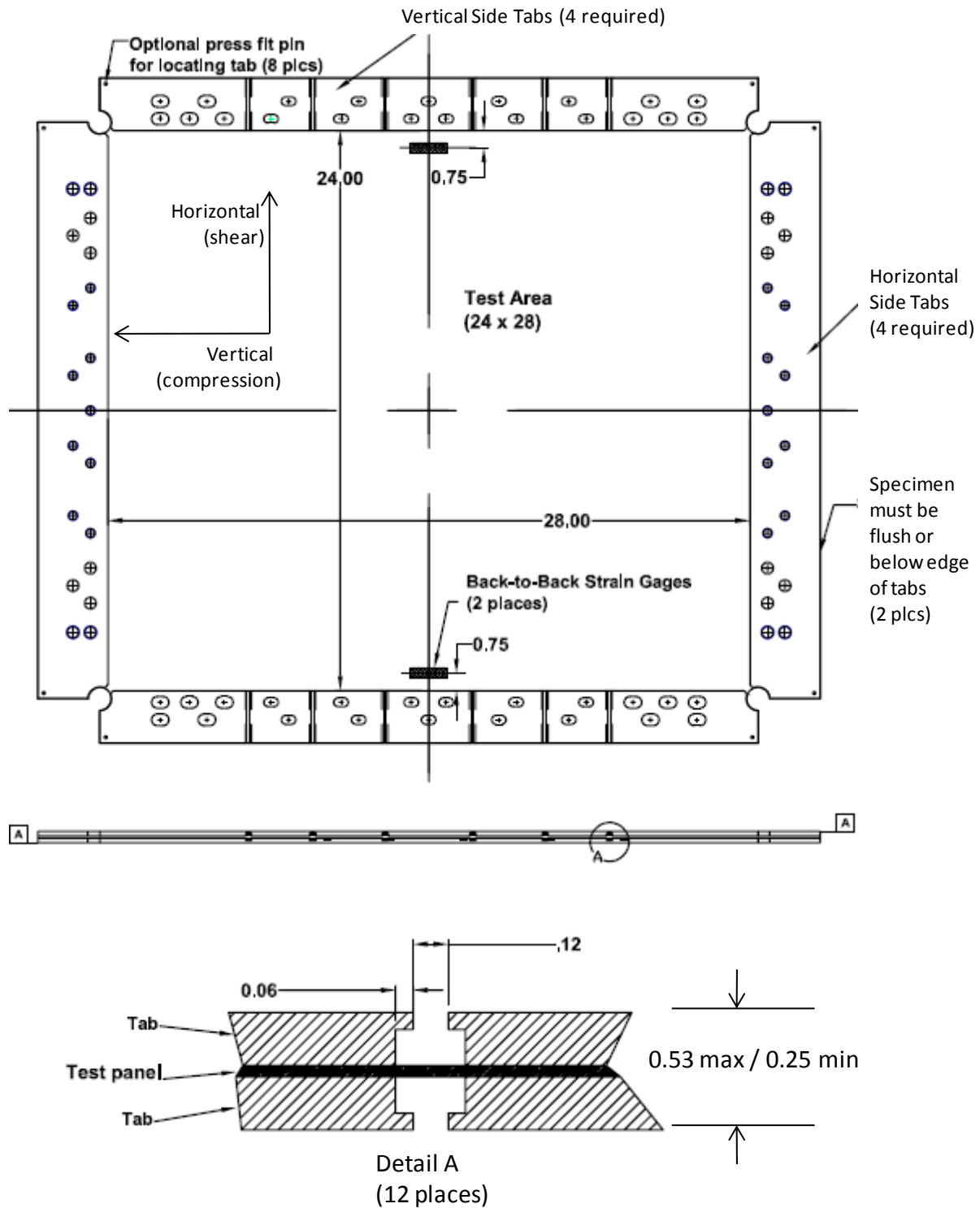


Figure 7. Test specimen with vertical and horizontal tabs attached. (All dimensions are in inches.)

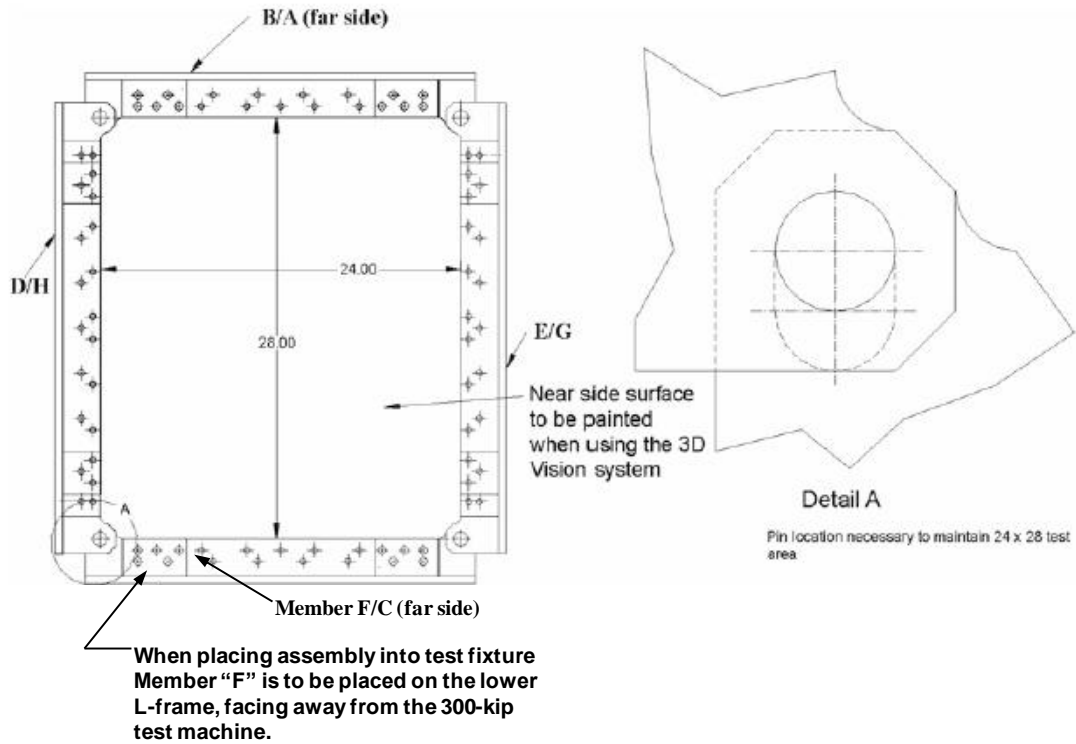


Figure 8. Frame for attachment to test specimen. (All dimensions are in inches.)

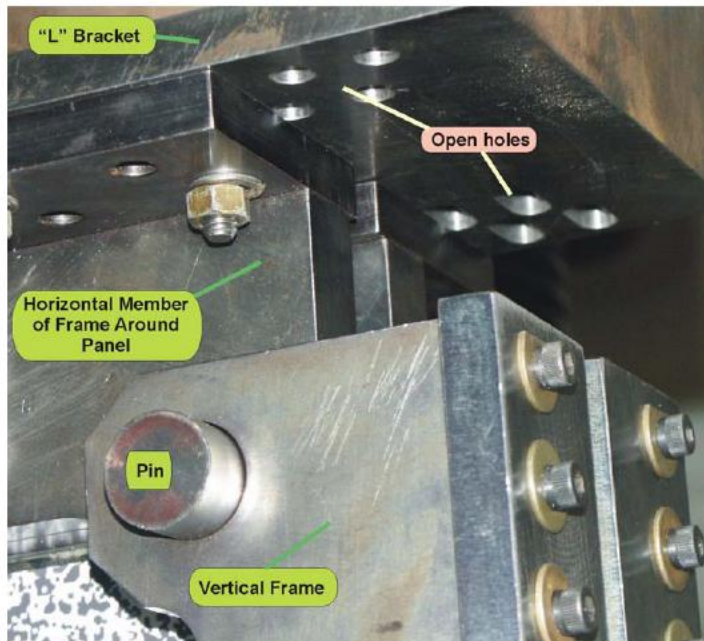


Figure 9. Corner pin in specimen/frame subassembly.

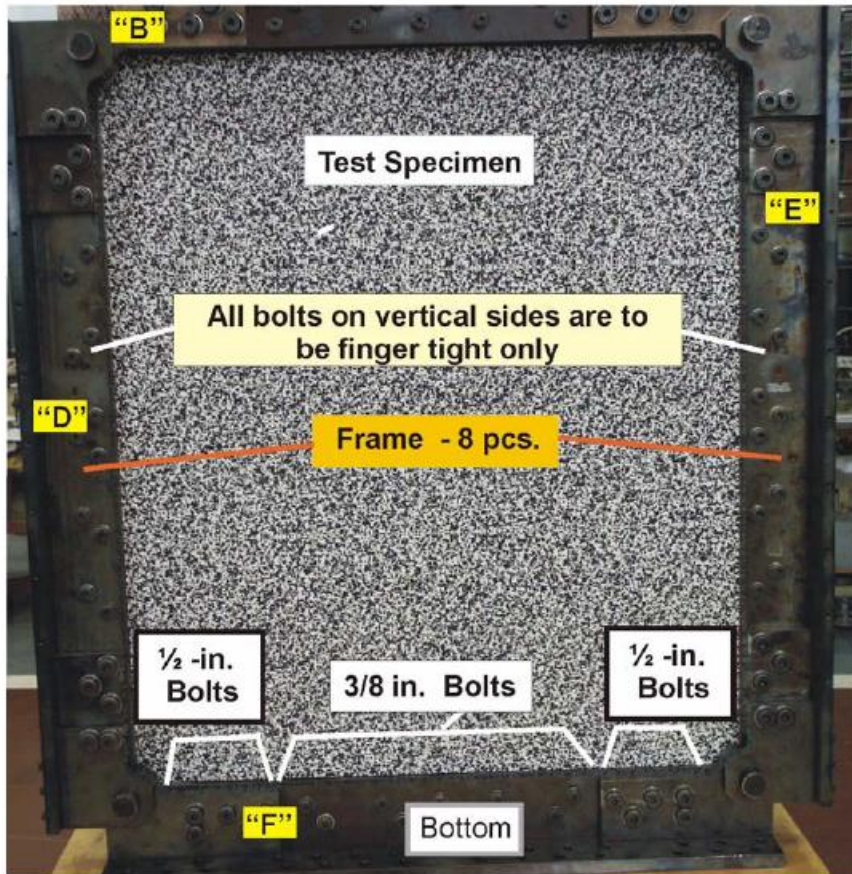


Figure 10. Photograph of specimen/frame subassembly.

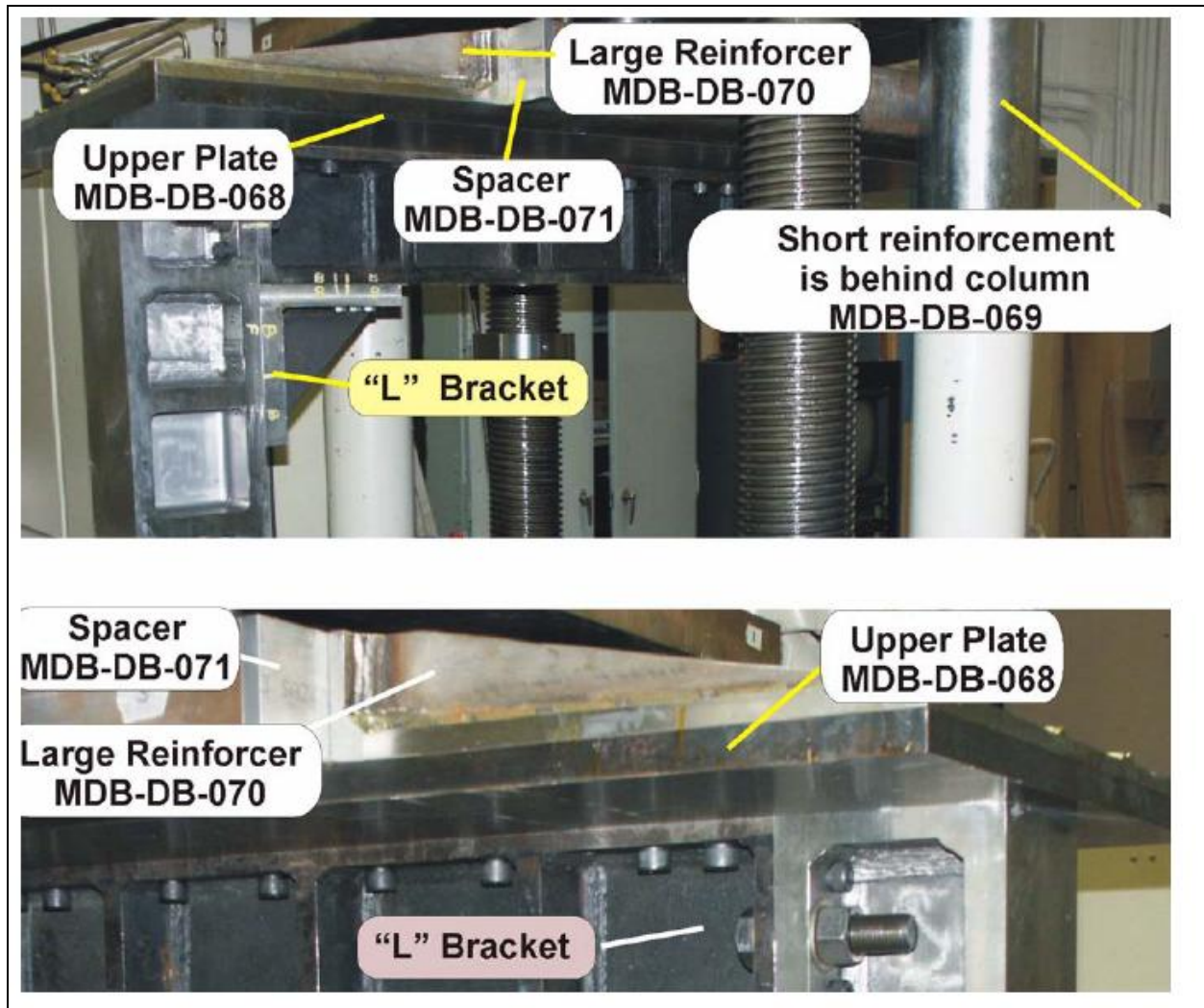


Figure 11. Upper CLTF frame assembly.

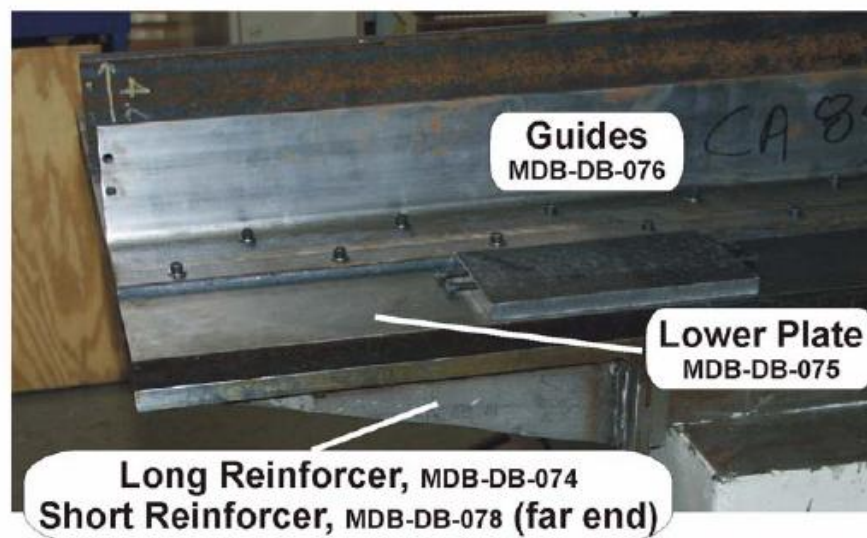
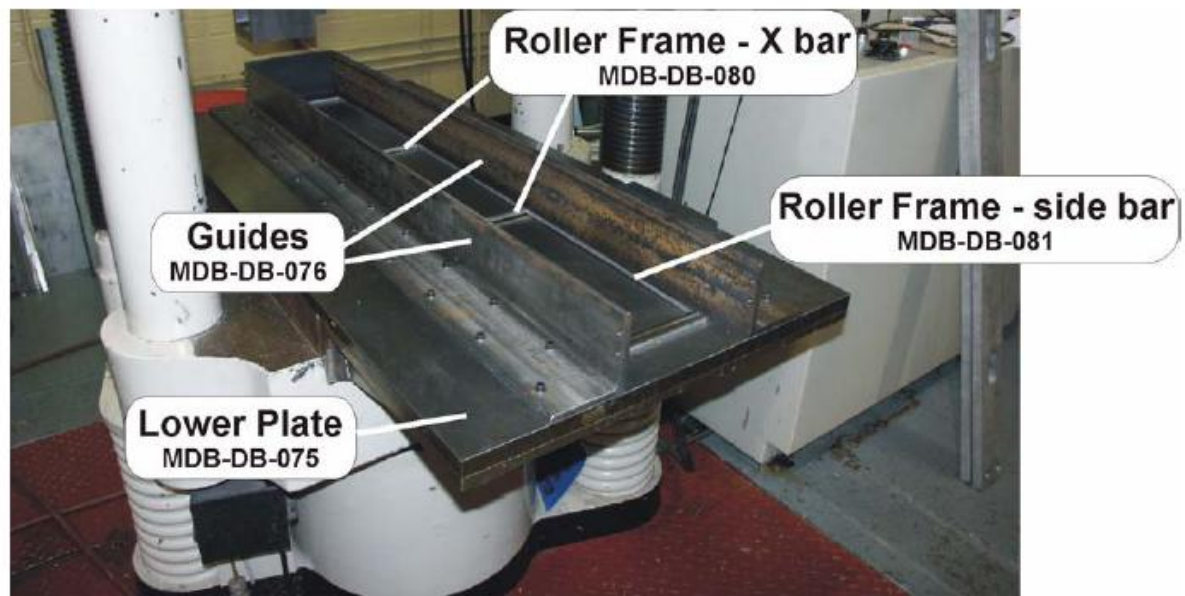


Figure 12. Lower CLTF frame assembly.

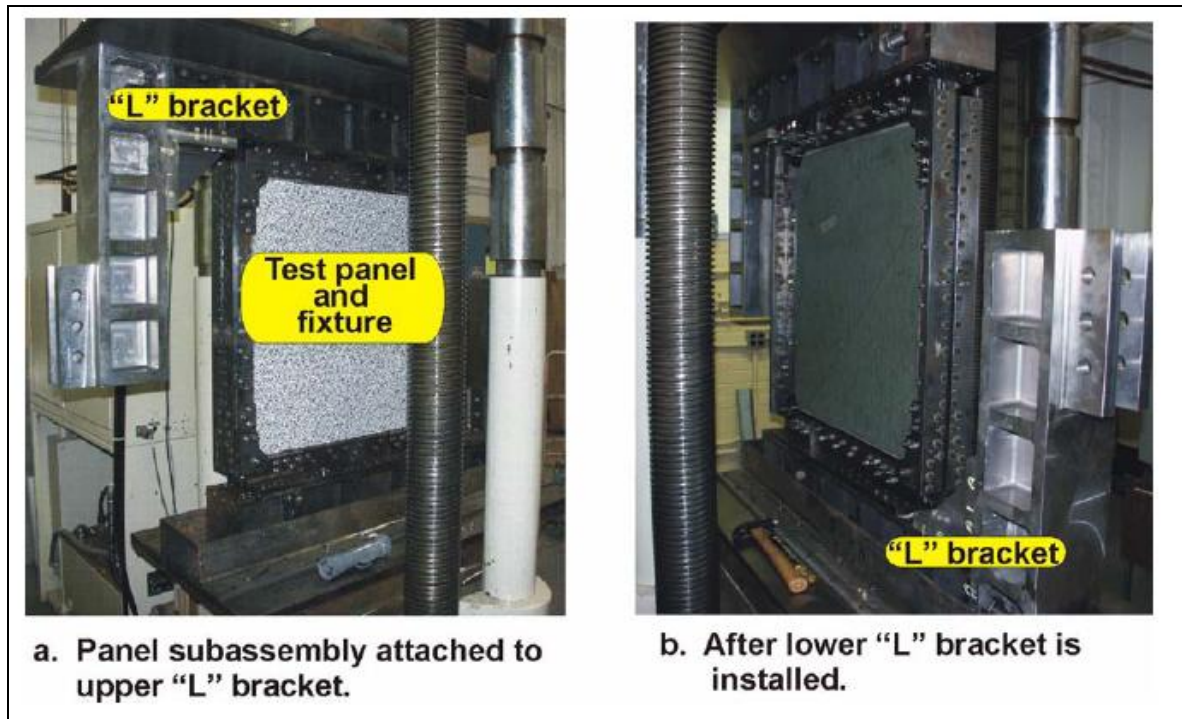


Figure 13. Installation of specimen/frame subassembly and lower "L" bracket into test machine.

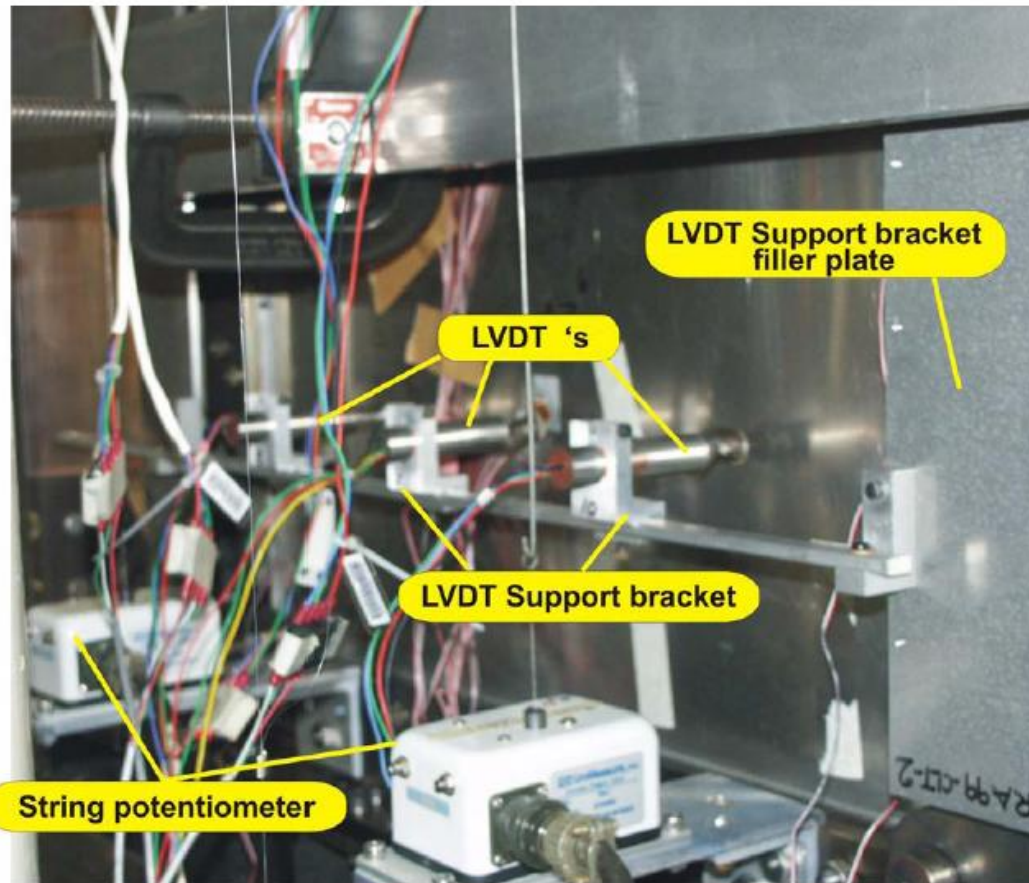


Figure 14. Installation of support hardware for displacement transducers.

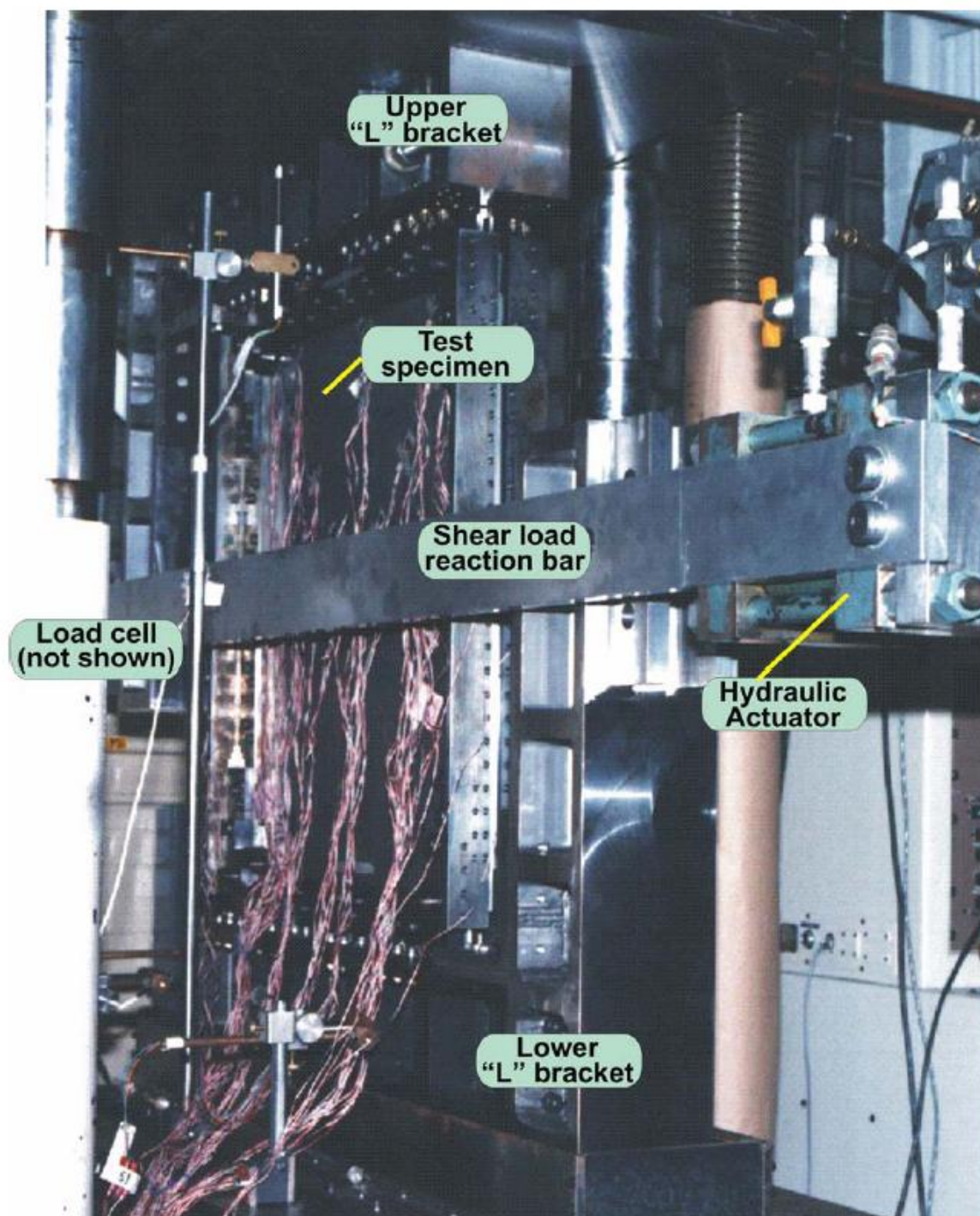


Figure 15. Shear load mechanism installed into CLTF.

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